The Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs

2nd Annual Workshop on Pharmaceuticals, Personal Care Products (PPCPs) and Endocrine-Disrupting Compounds (EDCs) in Wastewater

Proceedings from the Workshop held September 2009

Sponsored by the Massachusetts Department of Environmental Protection

Workshop Proceedings
Pharmaceuticals, Personal Care Products (PPCPs) and Endocrine-Disrupting Compounds (EDC) in Wastewater: Issues and Solutions
September 22, 2009

Hosted by the Massachusetts Department of Environmental Protection (MassDEP) at the Federal Reserve Bank of Boston

Workshop Background

On September 22, 2009, a workshop for a continuing dialogue with stakeholders from industry, government, environmental groups, research, academia, and others on the issue of PPCPs and EDCs in wastewater, including treatment plant effluent used for recharge, and soil adsorption systems in unsewered areas was held at the Federal Reserve Bank of Boston. The focus of this workshop was on evaluating the occurrence, fate, transport, and treatment effectiveness in surface and subsurface waters, and the best approaches to protecting human health and the environment given the presence of these compounds in wastewater.

Open discussions included:

- Re-using wastewater while still protecting human health and the environment
- Gaps that need to be filled, in the context of future research needs
- Identifying the most feasible and effective risk reduction strategies

Workshop Summary

Welcoming Address

Laurie Burt, Commissioner of the Massachusetts Department of Environmental Protection provided the welcoming address. She noted that MassDEP is among the many federal, state, and non-profit entities world-wide that are increasingly committed to evaluating the potential impact of Pharmaceuticals, Personal Care Products, and associated Endocrine-Disrupting Compounds and to developing the best practices for managing and treating these substances as our science evolves. Only recently has analytical capability existed to measure these materials at the low concentrations in which they are found, and the science to assess the potential risks posed to humans and our ecosystems is still very young.

She highlighted two drinking water research efforts on which MassDEP collaborated. One was the United States Geological Survey (USGS) and the United States Environmental Protection Agency (EPA) study launched last year to check for the presence of pharmaceuticals and personal care products in drinking water at about 30 drinking water facilities across the country. MassDEP partnered with USGS and EPA to take monthly samples from the raw and finished water at the Lowell Regional Water Utility, which draws its raw water from the Merrimack River. USGS analyzed the samples for more than

280 compounds, including those associated with pharmaceuticals and personal care products. The formal results of this study will not be ready for release until late 2010, but in Lowell MA they detected only two of the 280 compounds in the raw water: caffeine and acetaminophen (i.e., Tylenol) at very low concentration.

The Commissioner shared that EPA and the USGS will embark on a second round of research that will build upon the work conducted. In the new study, EPA intends to expand the number of drinking water facilities to about 50 nation-wide, and plan to gather additional information form each of the participating drinking water treatment plants via a questionnaire.

MassDEP is also partnering with UMass-Amherst and A-E-COM on a study to evaluate how effectively the drinking water treatment plants of 15 utilities remove PPCPS and EDCs. The project will identify any metabolites (i.e. daughter products) and includes an aquatic bioassay that identifies adverse effects in fish. Launched in 2008, this research will make three major contributions to the field of drinking water treatment:

- First, it will provide information on the effectiveness of ozone/biofiltration for the removal of a wide range of EDCs, PPCPs, their daughter products and associated endocrine activity.
- Second, it will provide engineers and operators with key information on how to best design and run ozone/biofiltration systems for optimal control of these compounds.
- Finally, it will provide utilities with information on likely removals of these compounds under a broad range of water qualities and treatment scenarios.

Commissioner Burt noted that as this study proceeds, MassDEP will continue to evaluate the occurrence and treatment effectiveness of Massachusetts drinking water systems.

Workshop Presenters:

- Dr. Nicholas Anastas, MassDEP, Bureau of Resource Protection, Drinking Water Program
- Dr. James Crook, Consultant, National expert on water reclamation and reuse projects
- Dr. Bruce Brownawell, State University of New York, National expert on fate and transport of PPCPs in the environment
- Mr. George Heufelder, M.S. R.S., Director, Massachusetts Alternative Septic System Test Center
- Mr. Marcel Belaval, B.S., M.S., U.S. Environmental Protection Agency, Region 1.

A Day in the Life of a Medicine: Identifying Opportunities for Risk Reduction

Dr. Nicholas Anastas, MassDEP, Bureau of Resource Protection, Drinking Water Program;

Abstract: Medicines have contributed to increased longevity and improved quality of life. Whether these medicines have their origins in Nature (e.g., aspirin, morphine, Taxol), or if they are the laboratory-based products crafted by the skilled hands of a medicinal chemist, these pharmaceuticals and personal care products (PPCPs) occupy a central role in modern society. Recently, PPCPs have been detected in surface waters (lakes, ponds and streams), groundwater and drinking water, as well as sediments, sewage sludge and aquatic organisms. The reported concentrations of these compounds are generally low, often in the part per billion range and lower. However, research results show that compounds that act on the endocrine system, the so-called endocrine-disrupting chemicals (EDCs), can adversely affect aquatic organisms and other wildlife. The potential adverse outcomes in humans exposed to low levels of a mixture of PPCPs and EDCs over a long period of time are currently unknown, making it an area of active research and discussion. Prudent public health policy demands risk reduction at each stage in the lifecycle of a medicine. The "lifecycle of a medicine" is a term used to include all PPCPs and can be represented by four phases: 1. Discovery and development; 2. Manufacture and distribution; 3. Prescribing and compliance, and 4. Disposal and treatment. This presentation provided an overview of each phase of the lifecycle, identifying issues and potential opportunities for risk reduction during each phase.

Presentation Slides: ..\PPCP Conference 2009\NDA PPCP Wastewater Conference 9 22 09.ppt

The Role of treatment in reducing the environmental load of PPCPs/EDCs

Dr. James Crook, Consultant, National expert on water reclamation and reuse projects;

Abstract: Studies have indicated that PPCPs, some of which are EDCs, have adverse effects on aquatic animals in water bodies that receive discharges from wastewater treatment plants. While planned indirect potable reuse using reclaimed water has been practiced in the U.S. since 1962, the number of potable reuse projects has increased substantially in recent years and questions have arisen regarding potential human health effects of PPCPs and EDCs in reclaimed water used for potable supply. Due to the concerns associated with PPCPs and EDCs, extensive monitoring of reclaimed water destined for potable reuse has been conducted at several potable reuse projects in the U.S. and elsewhere. Potable reuse projects are required to meet stringent reclaimed water treatment process requirements and water quality limits for specific unregulated chemicals and/or surrogate constituents. Treatment process requirements range from tertiary treatment followed by soil aquifer treatment for groundwater recharge via surface spreading, to advanced wastewater treatment processes (including organic removal processes such as reverse osmosis and advanced oxidation) for groundwater recharge via direct injection or surface water augmentation of raw water supplies. This presentation included information on reclaimed water treatment processes used at existing potable

reuse project, data on organics removal from several research studies, and monitoring data from existing potable reuse facilities on the reduction/removal of PPCPs and EDCs

Presentation Slides: ..\PPCP Conference 2009\Crook - EDCs & PPCPs, 8-29-09.ppt

Levels of Occurrence and Fate of PPCPs of Concern in Municipal Sewage Sludges, Biosolids, and Sediments

Dr. Bruce Brownawell, State University of New York, National expert on fate and transport of PPCPs in the environment; PPCPs and EDCs in Sediments, Sewage Sludge and Biosolids.

Abstract: Many organic contaminants, or their metabolites, present in municipal waste water are particle reactive and can both accumulate in sewage sludge or be found at relatively high levels in sediments in sewage affected bodies of water. This presentation reviewed the levels of occurrence and fate of PPCPs of concern in municipal sewage sludges, biosolids, and sediments. Two specific cases were discussed: 1) the sources, occurrence, transformations, and fate of potential endocrine-disrupting contaminants in sewage affected sediment environments, specifically nonylphenol ethoxylate metabolites, natural steroid estrogens, and 2) the discovery of surprisingly high levels of quaternary ammonium compounds in sediments, (e.g., sewage sludges, biosolids). These compounds are very particle reactive cationic surfactants that are widely used as fabric softeners, hair care products, disinfectants, and in a variety of other personal care products. The environmental levels and persistence of these surfactants and their metabolites would not have been predicted based on risk screening methods typically employed or some of the data that are available concerning fate or volume production of these chemicals. The lessons that might be learned from these examples were discussed.

Presentation Slides: Not Available

The Fate of Selected Pharmaceuticals and Other Organic Compounds in Wastewater Discharged Through Onsite Septic Systems

Mr. George Heufelder, M.S. R.S., Director, Massachusetts Alternative Septic System Test Center;

Abstract. Domestic wastewater potentially contains a number of organic compounds including pharmaceuticals, endogenous hormones, personal care products and cleaning products. When domestic wastewater is discharged through onsite septic systems, its incomplete treatment presents the potential for intersecting drinking water wells and other sensitive environmental receptors. This presentation reviewed work performed at Massachusetts Alternative Septic System Test Center in cooperation with the U.S. Geological Survey relating to removal capabilities of standard and advanced onsite

treatment systems, and compared these findings with results from other studies that investigated onsite septic systems. The presentation reviewed the state of our present understanding regarding the removal of organic wastewater compounds by standard onsite septic system treatment processes and identified future research needs.

Presentation Slides: ..\PPCP Conference 2009\DEPSummitGeorgeHeufelder.pdf

Overview of Federal Research Regarding PPCPs/EDCs in Wastewater

Marcel Belaval, B.S., M.S., Hydrologist, United States Environmental Protection Agency, Region 1

Abstract: This talk provided an overview of PPCP studies being conducted nationally by EPA. The US Environmental Protection Agency (EPA) has several ongoing research studies looking at occurrence, fate & transport, exposure, and effects of PPCPs. EPA studies underway include a national rivers and streams assessment looking at fish tissue contaminants, an EPA / USGS collaborative study on PPCPs in drinking water, an evaluation of drinking water treatment technologies for removal of endocrine-disrupting chemicals, and others. The talk will include a summary of recent findings as well as a list of areas requiring further investigation and research.

Presentation Slides: ..\PPCP Conference 2009\MassDEP Pharms in Water Belaval (no data ver).ppt

Next Steps and Conclusions Identified by Workshop Participants

A recommendation was made that the workshop participants continue to work together and make progress on many of the good ideas raised at the workshop. The following conclusions were made for Wastewater and Wastewater Re-use; Septic Systems and Soil Adsorption Systems; and Additional Research and Information Needs.

Primary Conclusions: Wastewater and Wastewater Re-use

- The ability of secondary and tertiary treatment to remove PPCPs and EDCs is highly variable.
- Tertiary treatment and soil aquifer treatment reduce many – but not all – PPCPs and EDCs to very low levels.
- Advanced wastewater treatment processes (such as reverse osmosis and advanced oxidation) effectively reduce most PPCPs and EDCs to extremely low levels (many of the compounds are below detection limits).

- There is little information on whether EDCs and PPCPs become concentrated in vegetation or in soil, following wastewater re-use. Many of these compounds degrade over time.
- There is no evidence to suggest that EDCs and PPCPs at levels commonly found in reclaimed water present a health risk for non-potable applications of the water.
- Tertiary treatment followed by soil aquifer treatment is not as effective at removing PPCPs and EDCs as advanced wastewater treatment with reverse osmosis followed by ultraviolet disinfection (UV).
- Based on limited data, it appears that granular activated carbon is not as effective at removing PPCPs/EDCs as reverse osmosis, particularly for androgens (e.g., testosterone) and pharmaceuticals.

Research Needs: Wastewater and Wastewater Re-Use

- National research is needed on maximizing treatment efficiencies for PPCPs and EDCs. Current wastewater and drinking water treatment systems were not designed to remove very water soluble compounds, including PPCPs and EDCs. That said, UV disinfection seems to be effective at removing PPCPs and EDCs and many wastewater treatment plants already use UV disinfection.
- More research is needed to determine the extent and gravity of antibiotic-resistance in microorganisms and micro-flora resulting from PPCPs in municipal wastewater and receiving waters.
- Gaps in knowledge include:
    - Identification of appropriate indicators/surrogates
    - The effectiveness and reliability of unit treatment processes
    - Analytical monitoring methodologies
    - Risk assessments/Maximum Contaminant Levels for individual constituents
    - Potential health effects of mixtures (e.g., synergistic or additive effects)
    - Concentration and significance of degradation byproducts

Primary Conclusions: Septic Systems and Soil Adsorption Systems

- Of the two types of systems tested at the Massachusetts Alternative Septic System Test Center, a standard septic tank-soil absorption system (Title 5) was better at removing PPCPs than recirculating sand filters.
- For many of the PPCPs investigated, a drip dispersal unit (which presumably incorporates plants to some degree into the wastewater treatment), reduced the majority of these compounds to the detection limit.

Research Needs: Septic Systems and Soil Adsorption Systems

- Further research is needed on engineering septic systems to maximize the breakdown of PPCPs and EDCs from wastewater. Among the controllable variables are pH, oxygen, carbon and clay content and soil texture. The composition of the

biological community also affects the metabolism of these compounds and the composition of the communities can be altered to encourage full mineralization.

- The forum identified several promising modifications to septic systems that could enhance PPCP removal. Useful research projects would include reengineering the design of septic system to placing the systems closer to the surface where plant uptake can play a role, determining what species of grass are most effective in assisting removal, capitalizing on the ability of fine soils and clays to remove PPCPs, and considering adding organic material to further enhance removal.

<u>Other Research Needs Proposed Follow-up Suggestions</u>

- REACH-Type Program to Rank Chemicals for Research: Unlike Europe, the United States lacks a comprehensive and systematic mechanism for identifying potential health and environmental hazards from PPCPs and other chemicals. The European Union has adopted REACH (Registration, Evaluation and Authorization of Chemicals) as enabling legislation as part of a prioritization strategy to minimize risk early in the chemical development and manufacturing stage. REACH places the onus on the manufacturer and importer of chemicals to provided hazard data on all chemicals used in commerce. Reducing hazard as part of a pollution prevention strategy mitigates the stress on downstream activities, i.e., treatment. A REACH-like approach that ranks and prioritizes chemicals for further research was encouraged by several speakers.
- Improved Communications/Information Exchange between Industry & Environmental and Public Health Agencies: Toxicity data useful for human health risk assessment is lacking. The human health data generated by the pharmaceutical companies are generally geared toward clinical uses and are therefore not completely useful for risk assessment purposes. However, some of these data can be useful for relative ranking and research prioritization. Supporting efforts for improved information transfer between the pharmaceutical industry and environmental/public health agencies should be encouraged.
- Aquatic Ecology Impacts: On an international level, published scientific studies provide documented evidence for adverse outcomes in aquatic and wildlife populations, to concentrations of PPCPs and EDCs reported in the environment. Massachusetts-specific data are lacking. Massachusetts can look for opportunities to partner with EPA, other state and environmental groups to generate PPCP/EDC occurrence data and support research on identifying ecological hazard of PPCPs and especially EDCs.

Appendix A

Speaker Biographies

Pharmaceuticals, Personal Care Products (PPCPs) and Endocrine-Disrupting Compounds (EDC) in Wastewater: Issues and Solutions
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Nicholas D. Anastas, Ph.D., M.S.
Nicholas Anastas holds a doctorate in Environmental, Earth and Ocean Sciences from the University of Massachusetts Boston and received a master's degree in pharmacology from Northeastern University. Dr. Anastas has worked in a variety of programs for the MassDEP since 1988. As a member of the drinking water program, he currently serves as the technical specialist on emerging contaminants, specifically pharmaceuticals/ personal care products and endocrine-disrupting compounds, he is the quality assurance scientist for the program and coordinates the implementation of several Safe Drinking Water Act (SDWA) rules. Previously he was the Source Protection Group Leader responsible for developing policies for protecting surface and groundwater sources of drinking water from contamination. For thirteen years, he was a regulatory toxicologist and risk assessor for the MassDEP's Office of Research and Standards where he developed health-based approaches for characterizing human health risks, provided analytical chemistry support to the department and served as the chief Quality Assurance scientist for the MassDEP. Doctor Anastas has served as a board member of the North Atlantic Chapter of the Society of Toxicology and Environmental Chemistry (NAC SETAC) from 2001-2003; Vice President of the Groundwater Managers- Northeast Section 2003-2004 and Co-chairman of the Federal-State Toxicology and Risk Assessment Committee (FSTRAC) from 1997-2000. Nick has spoken at several nation conferences on Pharmaceuticals and Personal Care Products (PPCP) and has written several articles on the impacts of green chemistry to pollution prevention.

James Crook, Ph.D., P.E.
James Crook, Ph.D., P.E., is an independent environmental engineering consultant with more than 37 years experience in state government and consulting engineering arenas serving public and private sectors in the United States and abroad. He is an internationally-recognized expert in the area of water reclamation and reuse and has been involved in numerous projects and research activities involving public health, regulatory and permitting issues, risk assessment, and treatment technology. Dr. Crook currently serves on the National Water Research Institute Research Advisory Board, WateReuse Foundation Research Advisory Committee, and the American Water Works Association, International Water Association and Water Environment Federation Water Reuse

Committees. He received his B.S. degree in civil engineering from the University of Massachusetts and his M.S. and Ph.D. degrees in environmental engineering from the University of Cincinnati. Dr. Crook is certified as a Diplomate in the American Academy of Environmental Engineers and is a Registered Professional Engineer in California and Florida

Bruce Brownawell, Ph.D.
Bruce J. Brownawell is an Associate Professor at the School of Marine Sciences at Stony Brook University State University of Ney York. His research is focused on the trace level detection, transport, fate, and biological effects of anthropogenic organic chemicals in natural waters. Trace level analyses provide us with new opportunities for addressing environmental quality research topics; e.g., whether female steroid hormones or hormone mimics exist in sufficient quantities to cause observed feminization of male or sexually immature fish; potential uses of stable pharmaceuticals and surfactants as tracers of waste waters and sewage contaminated sediment; and better characterization of the toxicity to marine organisms of complex mixtures of anthropogenically-derived chemicals in the environment.

George Heufelder, M.S., R.S.
George Heufelder is the Director of the Barnstable County Department of Health and the Environment which serves Boards of Health in the 15 towns on Cape Cod, Massachusetts. In 1999, with others, Mr. Heufelder established the Massachusetts Alternative Septic System Test Center with grant support from EPA and Massachusetts Department of Environmental Protection. This Center, which he currently directs, is becoming established as one of the foremost third-party testing facilities and is serving as a resource for Boards of Health and other agencies regarding septic system performance. Mr. Heufelder is a Registered Sanitarian and has a B.S. and M.S. in Biology.

Marcel Belaval, B.S., and M.S
Marcel Belaval is a Hydrologist with the Drinking Water Program at EPA Region 1 where he provides technical guidance and assistance on groundwater investigations. Marcel is also working on the implementation of new drinking water regulations including Stage 2, the Radionuclides Rule, and the Ground Water Rule. He holds an M.S. in Geophysics from Boston College and a B.S. in Geology from the University of Connecticut.